PROJECT SAPPHIRE: INHIBITION OF COMBUSTION BY METAL-CONTAINING COMPOUNDS

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In response to the need to find replacements for Halon 1211 and especially for Halon 1301 for applications in which weight and volume constraints are severe, a basic research program is being conducted in our laboratories under sponsorship of the Air Force Office of Scientific Research (AFOSR). It has been known for several decades that traces of metal containing compounds significantly modify the burning characteristics both of propellants and of fires. Notwithstanding the use of selected metal-containing compounds in dry-chemical fire extinguishing systems, the mechanism of inhibition of the flame by metal-containing systems is not well understood. For this reason, a principal objective of our work is the understanding the chemistry of metals in flames. The tool selected for this investigation is a flame-molecular beam-mass spec-trometer, and this instrument is now on line. However, as this instrument was being built, it was decided to examine the heat extracted by the burner as a measure of the degree of extinguishment by an agent added to a premixed flame. To this end, a flat-flame burner, with provisions for measuring the heat extracted from the flame by the burner, has been operated both at atmospheric pressure and at reduced pressure (30 torr), and several agents (both currently used agents and candidates as next generation agents) have been characterized. The insights derived from this set of experiments have been unexpectedly rich and will be discussed. From a phenomenological point of view, a flame can be characterized as having an activation energy, and inhibition results from any process that reduces the number of radicals with energy in excess of the activation energy barrier. In this context, three distinctly different types of behavior have been observed: (1) thermal inhibition of the flame, (2) shifting of the stoichiometry toward the inflammability limit, and (3) catalytic recombination of flame radical . The effect of catalytic recombination of flame radicals is complicated by the fact that this process returns heat to the flame. Examples of each type of behavior will be presented, and the implications of the catalytic recombination mechanism will be discussed. Results will be presented both for a variety of "conventional" inhibiting agents and for iron-containing compound.